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TITLE: PERISTALTIC ROTATION PUMP WITH EXACT, ESPECIALLY MECHANICALLY LINEAR DOSAGE

Amendment A: REMARKS

Applicant respectfully re-submits the present Amendment "A" in a revised format in response to the Office communication of April 9, 2007. Claim 18 did not have a status identifier. Applicant respectfully contends that the present amendment is now in compliance with the required amendment practice under 37 C.F.R. § 1.121. The present amendment has been sent before expiration of the shortened statutory period for response such that a fee for extension of time is not currently due.

Upon entry of the present amendments, previous Claims 1 - 13 have been canceled and new Claims 14 - 23 substituted therefor. Reconsideration of the rejections, in light of the forgoing amendments and present remarks, is respectfully requested. The present amendments have been entered for the purpose of placing the claim language into a more proper U.S. format and for the purpose of more clearly distinguishing the present invention from the prior art.

In the Office Action, Claims 1, 2, 8 and 9 were rejected under 35 U.S.C. § 102(b) as anticipated by the Monk patent. Claims 3, 5, 7 and 11 were rejected under 35 U.S.C. § 103(a) as being obvious over the Monk patent. A substitute specification in proper idiomatic English was required. The title was object to and a new title was required. The drawings were also objected to.

As an overview to the present reply, Applicant has extensively amended the claim language

so as to place the claim language into a more proper U.S. format, including proper antecedent bases and proper structural interrelationships throughout. Any indefinite terminology found in the original claim language has been corrected herein. Additionally, a new Substitute Specification has been provided which clarifies the difficult English translation that was originally provide.

As an over to the present reply, it is important to note that there is a very great difference between mechanically linear and non-linear dosage. The pumping mechanical linearity means that the instantaneous mass flow rate is constant. On the other side, the pumping mechanical non-linearity involves variation of the instantaneous mass flow in time, although it is temporal average value is maintained also constant. Mechanical non-linearity of pumping in one pumping cycle is primarily caused by cyclical constriction (pressing) of the tubular element at the beginning of the occlusal path. The ejects a non-zero volume from the tubular element 1. Secondarily, mechanically non-linearity of pumping occurs by cyclical release of the pump segment after the end of the occlusal path. This results in a partial backward motion (disturbing) of the ejected (pumped) fluid. In this way non-uniform plus pumping occurs during each revolution.

Linear fluid dosage means that a continued constant volume ejection of the fluid per unit angle of angular displacement of the pump rotor in any part of a rotor revolution. Classical arrangement involving pulsing is describes in the Monk patent. That is why the Monk patent does not split the working path into three partial components and define them geometrically. These components include the lead-in path (the path along which the roller elements rolling start to constrict the tubular element before they are completely released); (2) the occlusal path (the path along which the roller elements rolling on the pinched pump segment eject fluid); and (3) the releasing path (the releasing path along which the roller elements release the pump segment).

The Monk patent has the working path involving angle of revolution of 180 °. It has roller elements and, consequently, three pulses occur during each rotor revolution. The Monk discloses a pulsing peristaltic rotation pump. A pump segment 81 is placed on a working path curved surface 121. The U-shaped wall 116 has, on its upper side, an upwardly facing curved surface 123 (see fig. 3 and column 4, line 51 - 52). Curved surface 121 is not grooved. The flexible tube 81 has its central portion extending adjacent the surface 121. The tube is pinched between the surface 121 and the roller elements 46 - 48 on the rotor 42 as the rotor 42 rotates so that fluids are conveyed through the tube 81, colun111 5, line 22 - 34.

The peristaltic rotation pump under the Monk patent involves only the concept of the working path. It does not operate with its partia1 sections, i.e. lead-in, occlusal and releasing paths. It has no "supporting occlusal path"' which is elevated in the direction toward the rotor rotation center above the grooved working path. The position of the working path (curved surface 121) changes with respect to the motor shaft 43 and the rotor 42 (see column 5, line 33 - 34).

So as clearly distinguish the present invention, it now defined that there is "an outer housing" having an annular interior surface with a "first supporting surface and a second supporting surface". The surfaces define a working path. A groove is formed in the working path. There is an occlusal surface formed on opposite sides and above the groove. These features are neither shown nor suggested in the Monk patent. The Monk patent does not show the first supporting surface nor the second supporting surface which extend toward the exterior of the outer housing. The tubular element 1 is arranged so as to extend along the working path. The ends of tubular element leaned against and are fixed against the first and second supporting surfaces outside the working path. The tubular element 1 extends entirely around the working path. The pressure rollers roll along the

occlusal surface. These rollers simultaneously roll along the tubular element.

As a result of this construction of the present invention, the accuracy of the peristaltic pump achieves: (1) long-term and stable fixation of the tubular element along the working path of the pump; (2) exactly defined distances between the pressure roller and the tubular element at each point along the pump's working path; (3) mechanical splitting of the work path of the pump into three paths; and (4) mechanically-provided constant increments of the tubular element volume by gradually releasing the pressure roller from the tubular element located by the release path for leading the tubular element out of the occlusal path.

The pumping linearity of the present invention is insured by the removal of negative influence of the particular pressure roller since the pressure rollers is moving on the tubular element at the output from the occlusal path of the pump. In contrast, the peristaltic rotation pump of the Monk patent is just a common type of pulsing pump. It is not provided with an exact fixation of the tubular element into the groove of the working path. It does not involve the construction of the tubular element by the supporting occlusal path. The constant increment of volume in the tubular element in the releasing path per unit revolution of the rotor is not treated by geometric means and by the shape of the supporting occlusal path and the working path. On this basis, Applicant contends that the structure of the present invention, the function of the present invention and the results achieved by the present invention are patentably distinguishable from the prior art.

Herein, independent Claim 14 reflect the limitations of previous independent Claim 1. Dependent Claims 15 - 17 correspond, respectively, to the limitations of previous dependent Claims 2 - 4. Dependent Claim 18 corresponds to the limitations of previous independent Claim 6. Dependent Claims 19 - 21 correspond, respectively, to the limitations of previous dependent Claims

8 - 10. Dependent Claims 22 and 23 correspond, respectively, to the limitations of previous dependent Claim 22 and 23.

In view of the revised specification, it is not necessary to change the original drawings. The numbering is correct in accordance with the present revised specification.

Based upon the foregoing analysis, Applicant contends that independent Claim 14 is now in proper condition for allowance. Additionally, those claims which are dependent upon this independent claim should also be in condition for allowance. Reconsideration of the rejections and allowance of the claims at an early date is earnestly solicited. Since no new claims have been added above those originally paid for, no additional fee is required.

Respectfully submitted,

April 13, 2007 /Andrew W. Chu/

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~~PERISTALTIC ROTATION PUMP WITH EXACT, ESPECIALLY MECHANICALLY LINEAR DOSAGE~~

~~RELATED U.S. APPLICATIONS~~

~~Not applicable.~~

~~STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT~~

~~Not applicable.~~

~~REFERENCE TO MICROFICHE APPENDIX~~

~~Not applicable.~~

~~FIELD OF THE INVENTION~~

~~**[0001]** The invention deals with a peristaltic rotation pump with exact, mechanically linear dosage, designed particularly for use in medicine, half-operation medicine production and laboratories involved in any sphere.~~

~~BACKGROUND OF THE INVENTION~~

~~**[0002]** The peristaltic effect is based on the principle of gradual repeated ejection of the dosed media from a flexible container.~~

~~**[0003]** Gradual and repeated ejection of the media from the flexible container happens on a circular occlusal path by pressing a pressure roller onto a flexible pump segment and simultaneous shifting~~

~~of the roller in the direction of the longitudinal axe of the pump segment on the occlusal path pumps the media.~~

~~**[0004]** From the existing approach of all known designs of rotating peristaltic rotation pumps in their history it is obvious that the manufacturers only wanted to reach the pumping effect. All other objective criteria of pump quality as e.g. accuracy and linearity of dosage were less important as the so far known designs could not meet these qualities in principle as they were not able to fix the pump segment on the pump occlusal path and could not suppress the negative influence of the pressure roller when leaving the pump segment at the output of the pump.~~

~~**[0005]** The microprocessor regulation of movement of the pressing element on the pump segment and/or location of the pump segment in line with the gradual pressing by cams perpendicularly on the longitudinal axe of the pump segment represented some kind of improvement. The pump segment placed this way is well fixed on the linear occlusal path. As movement of the pressing roller in the direction of the pump segment longitudinal axe is not applied here, its pre-stressing cannot happen and thus changes of cross section cannot occur.~~

~~**[0006]** Significant reduction of the negative influence of the pressing element when leaving the pump segment on the output of the pump is not technically solved by this design solution either.~~

~~**[0007]** The most progressive known design so far solves the mechanical drawback of lack of dosing linearity and accuracy by microprocessor regulation of non linear movement of pressure rollers (pressure elements in general) both in one pumping cycle and more pumping cycles. Higher dosage accuracy and linearity can be achieved this way when the smallest dose of the pump (which is usually an integer multiple of the smallest volume ejected by one cycle) is specified, but only for bigger dosage volumes.~~

~~**[0008]** Non linear regulation in this instance means different speed of the pressure roller (pressure element in general) in different sections of the pump segment of one pumping cycle, the aim of which is to compensate mechanical non linearity of the chosen pump design by its opposite influence.~~

~~**[0009]** Mechanical non-linearity of pumping in one pumping cycle. is primarily caused by cyclical constriction (pressing) of the pump segment at the beginning of the occlusal path, which ejects a non-zero volume from the pump segment, and secondarily by cyclical release of the pump segment after the end of the occlusal path, which causes expansion of the flexible pumping segment and thus reception of the above mentioned non-zero disturbing volume ($V_{DISTURBING}$), causing pulsing of the pumped media and one-revolution non linearity of the dosed media at the pump output.~~

~~BRIEF SUMMARY OF THE INVENTION~~

~~**[0010]** The principal drawbacks of peristaltic rotation pumps, i.e. overall substantial inaccuracy of pumping and pulsing of the pumped media on the pump output during one revolution of the pump rotor are removed by the peristaltic rotation pump for exact dosing comprising of a pump segment located on a working path, and a rotor with pressure rollers, which is according to the invention based on the fact that the pump segment is extended to the working path, which is transversely grooved at the place of touch with the pressed pump segment, and is adjacent within its all length to an elevated circular supporting occlusal path for rolling at least two pressure rollers which are sliding mounted in pressing blocks located in the arms of at least double-arm rotor connected with a shaft of a stepping motor, while the supporting occlusal path is elevated in the central direction over the transversally grooved working path, which consists of a lead- in path, occlusal path and releasing path.~~

~~**[0011]** The pump segment is extended in the working path and both the ends of the pump segment are leant outside the working path on a supporting surface, and the pump segment forms angle α = 90° with the working path radius at the point of the pump segment diversion from the working path.~~

~~**[0012]** Mechanical linearity of dosing is ensured by the circular occlusal path and approximately circular releasing path adjacent within all its length with an elevated circular supporting occlusal path for rolling of at least of three pressure rollers. The angular length of the releasing path, corresponding with the distance from the beginning of releasing of the pump segment to the point of complete release--it means nothing force by the pressure roller on the pump segment, is the same as the angular length of the occlusal path and the supporting occlusal path is elevated above the occlusal path by the distance d < double of thickness of the pump segment wall and at the point of complete release of the pump segment the supporting occlusal path is elevated above the releasing path by the distance k, which is maximum the same as the external diameter of the pump segment.~~

~~**[0013]** The rotor is made of at least double-arm hollow profile in which the whole inside space of each hollow profiled arm contains a pressure block, each of them is divided by a longitudinal partition into two parts, a spring is located in each of the parts, the pressure blocks are secured in each arm of the hollow profile of the rotor within the length of their strokes by a pin placed in the lengthwise partition of the pressure block and moves in the first groove made in the arm of the hollow profile, the springs inside the pressure block are leant against the back wall of the sliding mounting, in which a roller is freely located from the other side, the springs are pre-stressed at the other end against the body located in the center of the hollow profile, the body is fixed with a locking close to the stepping motor shaft, the body is at least a trilateral prism.~~

~~**[0014]** For a double-arm rotor the body is a quadrilateral prism.~~

~~**[0015]** For a three-arm rotor the body is a trilateral prism the rounded vertexes of which mesh into the second socket at the place of connection of the hollow profile arms. The body is fitted with a protrusion on the front side, in which a locking spring is located, a locking groove and an inlet groove for the locking pin placed on the shaft are on the back side of the body, the width of locking groove in the most distant position is narrower, that the diameter of the locking pin.~~

~~**[0016]** The pin of the pressure block fits into the first groove symmetrically located in the front part of the hollow profile of the rotor, the pin locks at the same time into the appropriate second groove of the control element designed for handling the pressure block when locating to rotor to the working path, into which the pump segment is pressed by expansion. The control element is connected to a cylindrical extrusion by thread.~~

~~**[0017]** The minimum length of the occlusal path is defined by the size of the central angle of the pump rotor rotation and is calculated as 360°/number of rotor arms.~~

~~**[0018]** The pressure block is equipped with guiding grooves for transversal guiding of the pump segment on the grooved working path.~~

~~**[0019]** The pressure roller is a roller from a roller bearing, which slides with the whole cylindrical surface in the sliding mounting of the pressure block.~~

~~**[0020]** The sliding mounting is finished with wiping blades for removing of possible dirt in both directions of rotation, there are sockets in the head of the pressure block at the level of the wiping blades.~~

~~**[0021]** The stroke length of the pressure block moves between 1.1 to 2.0 multiple of the pump segment external diameter.~~

~~**[0022]** The pressure roller is an electric conductor and when it touched the speed contact or the position contact located on the supporting occlusal path at the point of the change from the lead-in path into the occlusal path, and with a common contact located against them on the edge of the occlusal path, is under electric current of very low voltage.~~

~~**[0023]** The pressure roller may also be magnetized.~~

~~**[0024]** By expansion of the pump segment and its leading on an arch of radius of about three to four times the radius of the occlusal path and by leaning of the ends of the pump segment against the supporting surfaces the basic radial pressure of the pump segment against the transversally grooved working path of the pump is into being. The pump segment length has to be by 2-5 per cent longer than the distance between the supporting surfaces of the pump segment in the pump box case measured on the working path perimeter. The rate of "compression" of the length is adequate to the pump segment diameter and the thickness of its wall. The pump segment has to be in the plane perpendicular to the main rotation axe of the pump even after pre-stressing of its length. The pre-stressing causes the basic forces pressing the pump segment to the occlusal path.~~

~~**[0025]** Lengthwise shifting of the pump segment on the working path of the pump in the direction of the rotor rotation is prevented by transversal grooving of the working path. The basic pressure forces the soft surface of the pump segment into the transversal grooves even when the pump is switched off, and then, when it is on the pressure roller moving on the pump section in longitudinal direction even increases this impression in the contact point.~~

~~**[0026]** The transversal cross section through the grooving has an advantageous shape of isosceles triangle of height between approx. 0.15 and 0.50 mm, depending on the pump segment radius and thickness of its wall.~~

~~**[0027]** Transfer of the excessive compressing force of the pressure roller to the supporting occlusal path prevents crushing and occurrence of undesirable or even harmful force causing through the movement of the pressure roller lengthwise movement of the pump segment, when the grooved occlusal path is smooth or worn out.~~

~~**[0028]** The pressure roller leaning also on the supporting occlusal path then cannot crush the pump segment by excessive force. It either cannot sink deeply in the soft pump segment by excessive force and thus generate an undesirable shifting force applied on the pump segment in the direction of its longitudinal axe (length).~~

~~**[0029]** The level of the pressure force of the pressure roller is adjusted automatically for variable working conditions of the pump by redistribution of the total pressure force between the grooved working path with inserted pump segment and the supporting occlusal path. The distance between the occlusal path and the supporting path has to be shorter by the manufacturing tolerance of the pumping segment than the double thickness of the wall of the pump segment.~~

~~**[0030]** The fixed distance of the supporting occlusal path from the transversally grooved working path defines the extent of clasp of the pump segment on the occlusal path and the releasing path for releasing of the pump segment from the occlusal path and thus also the volume ejected by the pressure roller from the pump segment only as a result of its radial application on the pump segment.~~

~~**[0031]** The source of pulsing (i.e. repeated releases of the compressed flexible container) cannot be removed, the consequences, i.e. the cyclical drop and increase of the ejected medium (pulsing) at the pump outlet in one cycle period can be removed mechanically, if the mutually correct correlation of geometrical dimensions is observed, i.e.~~

~~- equal lengths of the occlusal path and the releasing path for the guiding of the pump segment from the occlusal path; and~~

~~- constant increment of the pump segment volume at gradual release of the pressure of the pressure roller on the releasing path related to any unit of its length regardless the chosen way of mechanical clasp of the pump segment.~~

~~**[0032]** Mechanical linearity of the peristaltic rotation pump according to the invention is ensured by the equal angle lengths of the occlusal and the releasing paths. This condition can only be met with a three-or more-arm pump rotor.~~

~~**[0033]** The pump rotor arms have to be symmetrically situated in a circle, i. e. in the angle of 360º. The minimum length of the main occlusal path of the pump in angle degrees is defined from the formula 360º/number of the pump rotor arms. Fig. 1A shows location of the of the decisive parts of the pump in the pump case for three-arm rotor. The minimum length of the main occlusal path of the three-arm pump rotor is thus defined by the central angle 120˚, which can be extended by angle ß at the sucking part of the pump. The length of guiding the pump segment from the occlusal path has to be exactly 120˚ of central angle of the pump rotor swing for a three-arm rotor, as it ensures mutually continuous linkage of each pump rotor arm cycle to the next one.~~

~~**[0034]** For a four arm rotor the basic central angle of the arms is 90˚, for a five-arm rotor 72˚and, for six arms it is 60˚, etc.~~

~~**[0035]** With zero back pressure at the pump output only minimum pressure of the pressure roller is sufficient for closing the pump segment cross section and the excessive force of the pressing springs is compensated by reaction of the supporting occlusal path on which the pressure roller also rolls. When the back pressure increases the need to increase the pressing force of the pressure roller~~

~~increases. This happens automatically by reduction of the force applied by the same pressure roller on the supporting occlusal path.~~

~~**[0036]** The pressure roller of any of the pump rotor arms rolls on the supporting occlusal path and at the place of concurrence also on the pump segment placed in the working path. The pressing force of the roller is carried out by the sliding mounting of its surface in the pressure block. It is thus a unique combination of rolling and sliding friction of the pressure roller of the peristaltic rotation pump out of the rotation axe of the pressure roller. This holds the reaction of pressing force of the pressure roller in the sliding mounting in the pressure block of the pump rotor.~~

~~**[0037]** Positioning of the pump rotor in the pump case without dislocation of the pump segment on the working path is a substantive condition for reaching high pumping accuracy. The design of the hollow profile of the pump rotor, in the arms of which the pressure blocks move, enables to use the design space thus created for the biggest possible diameter, length and number of threads of spiral pressing springs. This ensures high stroke of the pressure roller and the softest possible characteristic of the pressing force, i. e. condition closest to the requirement, that the change of the pressing force of the pressure roller is approximately constant for the pressure block stroke.~~

~~**[0038]** When putting the pump rotor into the pump case with the pump segment already fitted it is necessary to avoid wrong displacement of the pump segment from the working path to the supporting occlusal path. It is ensured by simultaneous high stroke of all pressure rollers when putting the rotor in and by groove guiding of the pump segment in transverse direction in all the pressure blocks for both direction of the pump rotor rotation.~~

~~**[0039]** Easily disconnectable fixing of the pump rotor on the propulsive shaft of the step motor with self-adjusting clearance of the angle deviation in both directions of the rotor rotation is ensured by a locking close.~~

~~**[0040]**You turn the pump rotor placed on the beginning of the shaft so as the input groove for the locking pin is parallel with the locking pin on the shaft. You get over the back pressure of the locking spring located inside the body of the rotor hollow profile and after pressing to the limit position you turn the rotor by specific angle of approx. 30°-45°. When you release the pressing force gradually the locking pin locks into the groove. To dismantle the rotor proceed in reverse mode.~~

~~**[0041]** The locking groove has the same or less width in the limit position than the diameter of the locking pin is. This ensures permanent definition of the clearance by permanent pressing the locking pin into the groove by the pressing spring force during operation and even when the unit is worn out.~~

~~**[0042]** The torque of the step motor is transferred via the locking pin on the shaft and via the locking groove in the pump rotor body.~~

~~**[0043]** The peristaltic rotation pump is usually located in a case and the motor operation is controlled by a microprocessor or by a computer.~~

~~**[0044]** Accuracy of the peristaltic pump according to the invention achieves, and in numerous applications even outmatches accuracy and linearity of so far known alternative means of discrete and continuous dosage, and is determined by:~~

~~1) Long-term and stable fixation of the pump segment on the working path of the pump.~~

~~2) exactly defined distance between the pressure roller and the pump segment at each point of the pump working path.~~

~~3) Mechanical split of the working path of the pump into two paths of identical length, i. e.~~

~~a) occlusal path of the pump; and~~

~~b) releasing path for guiding the pump segment out of the occlusal path of the pump, and lead-in path of any length for guiding the pump segment into the occlusal path of the pump. These three paths form the working path of the pump segment of each pump.~~

~~4) Mechanically provided constant increment of the pump segment volume by gradual releasing of the pressure roller from the pump segment located by the release path for leading the pump segment out of the occlusal path.~~

~~**[0045]** Pumping linearity is ensured by removal of negative influence of that particular pressure roller, which is moving on the pump segment at the output from the occlusal path of the pump. Accuracy and long-term stability of the pump mechanical function then enables further substantial increase of dosage accuracy by microprocessor calibration for individually used pump segment.~~

~~**[0046]** The peristaltic rotation pump according to the invention is a series manufacturable product with tiny and also definite (i.e. not random) dispersion of functional parameters of one particular pump. It has an exact linear dependence of dosed volume on the number of steps (the angle of the rotor movement) of the pump.~~

~~**[0047]** This applies until occurrence of irreversible deformation of the pump segment not replaced by the user despite highlighted manufacturer's warning in the operation manual.~~

~~**[0048]** The linear dependence of the dosing volume on the number of steps (rotor movement angle) obtainable in practice enables usage of software correction of the accuracy of the dosed volume for~~

~~any chosen dose within individual calibration of a particular pump segment used, and thus increase substantially the accuracy range of the whole unit for a declared pumping dose.~~

~~**[0049]** The peristaltic rotation pump with exact dosage has the following advantages against the previous solutions:~~

~~* A) The pump is exact and mechanically linear from the design principle and these features are not substantially dependent on manufacturing tolerances of the individual mechanical components.~~

~~* B) Linear dependence of the dosed volume on the number of steps (angle of rotor rotation) of the pump is an indisputable advantage.~~

~~* C) The pump is also cheap to manufacture and does not require specialist installation and mechanical calibration in manufacturing, non- observance of which might cause later accuracy of the unit.~~

~~* D) It is a maintenance free device for the whole life period and the operation is simple. It only requires a few-minute training how to put the pump segment and the rotor into the pump case.~~

~~* E) the wide range of pumping parameters ranging from microliters to tens or hundreds of liters may be covered by just one or two design variations of the pump.~~

~~* F) It may be switched during operation by a control to both directions of rotation with no change in accuracy and linearity of pumping, i. e. it can be used as a compressing or suction pump. It is similar to sucking of medicine by an injection syringe and subsequent injection of the medicine into a patient's body.~~

~~* G) Liquids as well as gases may be pumped and dosed with the same accuracy.~~

~~* H) The dosage accuracy achieved with low costs may also be used in highly pure environment by using sterile sets, e.g. dosage of medicine by infusion pumps, dosage pumps operating in laminate boxes, laboratory distributors for small-series production, half operating medicine production etc.~~

~~* I) The low manufacturing costs with reaching the declared accuracy enable the pumps to be also used where the accuracy is not the decisive parameter (supplying nutrition in the digestion system, endoscopic operation of nee arthritis, sucking liquids from operation wounds, dialyse monitors etc.).~~

~~BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS~~

~~**[0050]** Fig. 1A shows schematically the rotation pump case with the pump segment and the rotor inside.~~

~~**[0051]** Fig. 1 b shows a detail of the occlusal path start~~

~~**[0052]** Fig. 2 shows an axonometric view of the dismantled pump~~

~~**[0053]** Fig. 3 a shows an axonometric view of the rotor from the front.~~

~~**[0054]** Fig. 3 b shows an axonometric view of the rotor from the rear.~~

~~**[0055]** Fig. 4 shows dismantled rotor system.~~

~~**[0056]** Fig. 5 a shows the rotor three lateral from the front.~~

~~**[0057]** Fig. 5 b shows the rotor three lateral from the rear.~~

~~**[0058]** Fig. 6 a shows the pressure block from the front.~~

~~**[0059]** Fig. 6 b shows the pressure block from the rear.~~

~~DETAILED DESCRIPTION OF THE INVENTION~~

~~**[0060]** The peristaltic pump for exact dosing consists of the pump segment 1 of external diameter 3.9 mm placed on the working path 24 of diameter approx. 65 mm and three-arm rotor 6 with pressure rollers 4. The pump segment 1 is from an infusion set normally available in medicine. The working path 2 is transversally grooved at the place of contact with the compressed pump segment 1, and is adjacent and is adjacent along the whole perimeter to the elevated supporting occlusal path 3, on which three pressure rollers 4 roll, sliding mounted in pressure blocks 5 fitted in arms 23 of the rotor 6. The pressure roller 4 is a roll from a rolling bearing of diameter 9 mm, made of hardened and lapped steel. The rotor 6 is made of a three-arm hollow profile 7, in which the whole hollow of the arms 23 is filled with three symmetrically located pressure blocks 5, in each of which springs 8 are located, separated by a longitudinal partition 13. The springs are pre-stressed against the body 22 placed in the hollow profile 7. The body 22 is a three lateral prism the rounded corners 35 of which fit into the second socket 34 at the place of connection of the arms 23 of the hollow profile 7, the body 22 has a cylindrical protrusion 29 at the front, on which a securing spring 17 is placed, a securing groove 19 is made in the back side of the body 22 and input groove 20 for securing pin 21 placed on the shaft 9 of the motor 10. The width of the securing groove 19 at the most distant position is narrower than the diameter of the securing pin 21 is.~~

~~**[0061]** The pump segment 1 is mechanically compressed to the working path 24, which consists of the lead-in path 15, occlusal path 2 and releasing path 16.~~

~~**[0062]** Both ends of the pump segment 1 lean against the supporting surface 18.~~

~~**[0063]** The supporting occlusal path 3 is elevated above the grooved occlusal path 2 by the distance d = 1.0 mm.~~

~~**[0064]** The pressure block 5 is provided with a guiding groove 11 for transversal guiding of the pump segment 1 on the grooved working path 24.~~

~~**[0065]** The stroke of the pressure block 5 is 7 mm, which is in the range of 1.1 to 2.0 multiple of the external diameter of the pump segment 1.~~

~~**[0066]** The pressure blocks 5 are secured inside the rotor 6 within the range of the stroke with a pin 12 placed in the front on the longitudinal partition 13 placed in the pressure block 5. The pin 12 locks into the first grooves 14 symmetrically located inside the hollow profile 7 of the rotor 6 and at the same time into the appropriate second groove 33 of the control element 32 designed for handling the pressure blocks 5 when the rotor 6 is being mounted to the working path 24 into which the pump segment 1 is pressed by expansion, the control element 32 is connected to the cylindrical protrusion 29 by thread.~~

~~**[0067]** The length of the grooves 14 is 7 mm + 0.8 mm for the securing pin 12. The rotor 6 is connected by the body 22 to the shaft 9 of the step motor 10 by a locking close secured by a securing spring 17.~~

~~**[0068]** The pressure roller (4) is an electric conductor and when it touches the speed contact (25) or the position contact (26) located on the supporting occlusal path (3) at the point of the change from the lead-in path (15) into the occlusal path (2), and with a common contact (27) located against them on the edge of the occlusal path (2), is under electric current of very low voltage.~~

~~**[0069]** To prevent unintentional rotation of the control element 32 during operation of the pump, there are depressions 30 to which protrusions 31 placed on the front side of the hollow profile lock 7.~~

~~**[0070]** Description of the function~~

~~**[0071]** 1) Before commissioning~~

~~**[0072]** You shift the pump segment 1 with its solid ends into the holders of the pump case equipped with supporting surfaces 18. After that you press the rest of the pump segment 1 to the grooved working path so as the pump segment 1 covers the lead-in path 15, the occlusal path 2 and the releasing path 16 at the same distance from the edge of the supporting occlusal path 3.~~

~~**[0073]** You shift the pressure blocks 5 into the arms 23 of the hollow profile 7 by means of the control element 32 and the rotor 6 is ready for free sliding into the pump case. You turn the input groove 20 in the body 22 of the rotor 6 parallel with the locking pin 21 placed on the shaft 9 of the step motor 10 and slide the rotor 6 on the shaft 9, you press it against the securing spring 17, turn right by 30˚; after that you release the pressure against the rotor 6. The pin 21 of the shaft 9 of the stepping motor 10 then locks in the securing groove 19 in the body 22 and the motor 10 is connected to the rotor 6 without any play.~~

~~**[0074]** When you turn the control element 32 back, the pressure blocks 5 slide out of the rotor 6 hollow profiles 7 arms 23, and the pressure rollers 4 lean against the supporting occlusal path 3 and also against the pump segment 1 located on the working path 24. At the same time the guiding grooves 11 of the pressure blocks 5 are ready to guide the pump segment 1 transversally on the working path 24.~~

~~**[0075]** With each switching on and without using the pumped medium the unit carries out an automatic functionality self-check via the electric position contact 26, which senses position of the pump rotor 6. By rotation of the rotor 6 with the pump segment 1 inserted any of the pressure rollers 4 rolls on the electric position contact 26 and the common contact 27 and causes their conductive connection. The electronic system immediately and with high angle accuracy determines the number~~

~~of steps of the stepping motor necessary to repeated turn of the rotor 6. To switching the same electric contact by the pressure roller of any further arm in any direction, and the electronic system carries out the test. The unit thus tests correct operation plays of all moving parts of the pump rotor 6 as well as accuracy of adjustment of the pressing force of the pressing springs 8.~~

~~**[0076]** The pump is thus able to determine the condition when it can or cannot ensure the correctness and accuracy of pumping.~~

~~**[0077]** 2) Pumping~~

~~**[0078]** You place the input hose fitted to the pump segment 1 into a vessel with the pumped medium, and the output hose, also fitted to the pump segment 1 into the vessel you want to dose the medium into.~~

~~**[0079]** After switching the unit on you fill the pump system (the hoses) completely by electric rotation of the rotor 6. Then you adjust the volume to be dosed, which will be automatically calculated into the necessary number of steps of the stepping motor 10. After pressing the Start button the rotor 6 of the pump starts turning and the programmed exact and linear pumping starts.~~

~~**[0080]** The pressure roller 4 of one of the rotor 6 arms 23, which moves on the supporting occlusal path 3 between the input and output hoses, when the rotor 6 turns, starts to press the pump segment 1 and thus reduce its cross section. Complete compression of the pump segment 1 by the pressure roller 4 always occurs at the most distant point 28 of the prolongation of minimum length of the main occlusal path, when the rotor 6 turns slowly.~~

~~**[0081]** When the rotor 6 rotation velocity increases, with higher viscosity of the pumped medium or with pumping against back pressure the right compression of the pressure roller 4 occurs, later in the direction of the pump rotor 6 rotation. At the rotor 6 speed, when the pressure roller does not connect~~

~~the electric speed contact 25 with the common contact 27, the electronic system interprets the speed as too high and slows down the rotation speed accordingly. Then the connection of the position contact 26 (located by approx. 4° in the direction of the rotor 6 rotation in relation to the contact 25) with the common contact 27 has to occur, which defines the beginning of the occlusal path 2 and reliability of the compression of the pressure roller for any rotation speed of the rotor 6, and thus pumping correctness and liability. The pump in this operation mode of maximum pumping speeds then guarantees correct compression of the pump segment 1 at the beginning of the occlusal path 2 and thus also the accuracy of pumping. Reading of rotation speed and also the position of the rotor 6 happens 3 times per revolution for a three-arm rotor, and so the regulation loop is quite stable at this speed range.~~

~~**[0082]** The pump is thus able to determine and not to exceed the maximum pumping speed, at which it still can guarantee correctness and accuracy of pumping even under variable operation conditions.~~

~~**[0083]** At the moment of compression of one of the pressure rollers 4 on the pump segment 1 and also on the electric position contact 26 the preceding pressure roller 4 is at the end of the occlusal path 2 and at the beginning of the releasing path 16.~~

~~**[0084]** Further slight turn of the rotor 6 shifts the above mentioned preceding pressure roller 4 to the releasing path 16, which causes opening the pump segment 1, tightly closed before that, by constant volume. Each further movement of the rotor 6 causes progressive release of the pressure roller 4 from the pump segment 1 by constant volume, which is supported by the transversally grooved releasing path 16. A relation geometrically unequivocally and repeatably defined between the supporting occlusal path 3 and the releasing path 16 by a constant volume increment of the pump segment 1 being released, related to the unitary angle of rotation of the pump rotor 6.~~

~~**[0085]** The pumped medium is forced out of the pump segment 1 and thus also out of the pump output by the pressure roller 4, which is moving at that moment on the part of the pump segment 1 adjacent to the occlusal path 2. The preceding pressure roller 4, which is moving on the pumping segment 1 adjacent to the releasing path 16, does not influence the pressure force of the pump, as the space inside pump segment 1 before and after this roller 4 is then connected and gradually filled with the medium forced by the next roller 4 moving on the pump segment 1 on the occlusal path 2. The above algorithm still repeating after each 120° of the three-arm pump rotor turn (or each 90° with 4-arm rotor, 72° with 5-arm rotor, 60° with 6-arm pump rotor etc.) really compensates the influence of the pressure roller moving on the pump output.~~

~~**[0086]** 3) After pumping~~

~~**[0087]** The unit switches off.~~

~~**[0088]** By turning the control element 32 of the rotor 6 the pressure blocks 5 slide inside the arms 23 of the hollow profile 7 of the rotor 6. Axial pressure on the rotor 6 causes higher compression of the spring 17 fitted in the hollow cylindrical protrusion 29 of the body 22 against the shaft (9) of the motor 10, and the securing pin 21 gets out of the securing groove 19. By turning the rotor to the left the securing pin 21 moves opposite the output groove 20 and the rotor 6 may be pulled of the shaft 9 of the motor 10. By turning the control element 32 in the opposite direction the pressure blocks 5 slide out and their pressing springs 8 get partly released.~~

~~**[0089]** You pull the pump segment 1 out of the space of the working path 24 and then out of the other space. Finally you remove the ends of the pump segment supported by the supporting surfaces 18.~~

~~**[0090]** Industrial Application~~

~~[0091] The peristaltic pump according to the invention is applicable anywhere, where accuracy of dosage of liquids or gases is required. It is especially designed for application in medicine and in chemical, physical or biological laboratories.~~

PERISTALTIC ROTATION PUMP WITH EXACT MECHANICALLY LINEAR DOSAGE

CROSS-REFERENCE TO RELATED U.S. APPLICATIONS

Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

NAMES OF PARTIES TO A JOINT RESEARCH AGREEMENT

Not applicable.

REFERENCE TO AN APPENDIX SUBMITTED ON COMPACT DISC

Not applicable.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to peristaltic rotation pumps with exact mechanically linear dosages. In particular, the present invention relates to peristaltic rotation pumps that are use in medicine, half-operation medicine production and in laboratories.

2. Description of Related Art Including Information Disclosed Under 37 CFR 1.97 and 37 CFR 1.98.

[0002] A peristaltic effect is based upon the gradual repeated ejection of a dosed media from a flexible container.

[0003] Gradual and repeated ejection of the media from the flexible container can occur on a circular occlusal path by pressing a pressure roller onto a flexible pump segment and simultaneous shifting of the roller in the direction of the longitudinal axis of the pump segment on the occlusal path so as to pump the media.

[0004] Existing rotating peristaltic rotation pumps have been created solely for the purpose of achieving the pumping effect. All other objective criteria of pump quality, for example, accuracy and linearity of dosage, are less important in the prior art. In particular, the prior art cannot meet these qualities, in principle, since they are not able to fix the pump segment on the pump occlusal path and could not suppress the negative influence caused by the pressure roller when leaving the pump segment at the output of the pump.

[0005] An improvement in the technology was achieved by the microprocessor regulation of movement of the pressing element on the pump segment and/or the location of the pump segment in line with the gradual pressing by cams perpendicularly to the longitudinal axis of the pump segment. The pump segment is placed this way is fixed on the linear occlusal path. Since there is no movement of the pressing roller in the direction of the pump the longitudinal axis of the pump segment, its pre-stressing cannot happen and, thus, changes of cross section do not occur. The prior art fails to achieve any significant reduction in the negative influence of the pressing element when leaving the pump segment and the output of the pump. As used herein, the term "pump segment" replies to a tubular member onto which the pressing element exerts a force. This tubular element is typically in the nature of a tube used in the dispensing of medicines.

[0006] Microprocessor regulation of the non linear movement of pressure rollers has been utilized in multiple pumping cycles. Higher dosage accuracy and linearity can be achieved in this way when the smallest dose of the pump is specified. Non linear regulation would require different speeds of the pressure roller in different sections along the tubular element during a single pump cycle. This compensates for the mechanical non linearity of the chosen pump design.

[0007] Mechanical non-linearity of pumping in a single pumping cycle is primarily caused by cyclical constriction of the tubular element of the beginning of the occlusal path. This ejects a non-zero volume from the pump segment. Additionally, cyclical constrictions are also achieved by cyclical release of the tubular element after the end of the occlusal path. This causes expansion of the flexible tubular member and, thus, reception of the above described non-zero volume. This will cause a pulsing of the pumped media. There is also achieved a one-revolution non-linearity of the dosed media at the pump output.

BRIEF SUMMARY OF THE INVENTION

[0008] The present invention overcomes the principal drawbacks of peristaltic rotation pumps. In particular, this overcomes the overall substantial inaccuracy of the pumping and pulsing of the pumped media on the pump output during one revolution of the pump rotor. The peristaltic rotation pump of the present invention achieves exact dosing. The peristaltic rotation pump of the present invention comprises tubular element located on a working path within an outer housing. A rotor is provided with pressure rollers. The working path of the outer housing is grooved along the working path. The tubular element is received within this groove. There is circular supporting occlusal surface on opposite sides of the groove such at least two pressure rollers will roll along such an occlusal surface. These pressure rollers are slidably mounted in pressing blocks located in the arms

of a triple-arm rotor. The rotor is connected to a shaft of a stepping motor. The occlusal surface is elevated in the central direction at an elevation above the bottom of the groove. The working path can include a first supporting surface, the occlusal path, and a second supporting surface. The first supporting surface is the lead-in path. The second supporting surface is the releasing path.

[0009] The tubular element is extended in the working path. The tubular element has a first portion that is received against the first supporting surface and a second portion the is received against the second supporting surface. The tubular element forms a 90° angle with respect to the working path radius at the point at which the occlusal surface extends to either the first supporting surface or the second supporting surface.

[0010] Mechanical linearity of dosing is in ensured by the circular occlusal surface and the approximately circular releasing path. The annular length of the releasing path corresponds with the distance from the beginning of the releasing of the tubular element to the point of complete release. As such, it creates no force onto the pressure roller of the pump segment. This is the same as the angular length of the occlusal surface and the supporting occlusal path which is elevated above the bottom of the groove by a distance double the thickness of the wall of the tubular element.

[0011] The rotor is formed of a triple-arm hollow profile in which interior surface of the rotor contains a respectively plurality of pressure blocks in each of the arms. Each of the pressure blocks is defined by a longitudinal partition into a first part and a second part. A spring is located in each of the first part and the second part. The pressure blocks are secured in each arm of the rotor within the length of their strokes by a pin extending from the pressure block and into a groove formed in the arm of the rotor. The springs within the pressure block are urged against a back wall of the pressure block. A roller is freely mounted at the end of the pressure block. The springs are pre-stressed at the

other end against a body located in the center of the rotor. The body is affixed adjacent to the shaft of the stepping motor. The body has a trilateral prism shape.

[0012] The trilateral prism shape of the rotor includes rounded ends which are received within respective sockets formed on the interior of the arms of the rotor. The body has a cylindrical protrusion on side thereof. A locking spring engages this cylindrical protrusion. The body has a locking groove and an inlet groove suitable for receiving a locking pin placed on the shaft of the stepping motor. The locking groove and the inlet groove are formed on the backside of the body. The width of the locking groove has a width at an end opposite the shaft which is narrower than a diameter of the locking pin.

[0013] The pin of the pressure block fits into a first groove symmetrically located in the front part of the rotor. The pin locks also into another groove of the control element. The control element is threadedly connected to a cylindrical protrusion.

[0014] The pressure block has guiding groove for transversely guiding the tubular element along the grooved working path. The pressure roller is in the form of a roller bearing of a cylindrical shape. The pressure roller is rotatably mounted within the sliding mounting of the pressure block. The sliding mounting is provided with the wiping blades for removing possible dirt in both directions of rotation. There are sockets in the head of the pressure block adjacent to the wiping blades.

[0015] The pressure roller can be an electrical conductor. In particular, there can be position contacts located at the juncture of the occlusal surface with the first supporting surface and at the juncture of the occlusal surface with the second supporting surface. As the pressure roller moves and rotates, it can contact the electrical conductors. The contactors have a current of a very low voltage. Alternatively, the pressure roller may be magnetized.

[0016] The present invention achieves several advantages. By the expansion of the tubular element and its extension along an arch of a radius of about three to four times the radius of the occlusal surface, and by leaning the ends of the tubular element against the supporting surfaces, the basic radial pressure of the tubular element against the grooved surface of the occlusal path the tubular element achieves the desired basic radial pressure. The tubular element has a length that is two to five percent longer than distance between the first and second supporting segments. The rate of "compression" of the length of the tubular element is adequate for the diameter and thickness of the wall of the tubular element. The tubular element is in a plan perpendicular to the main axis of rotation of the pump even after of a pre-stressing of its length.

[0017] The present invention prevents length wise shifting of the tubular element along its working path in the direction of the rotor rotation as a result of the grooving of the occlusal surface. The basic pressure forces the soft surface of the tubular element into the groove even when the pump is switched off. The groove has a transverse cross section of an isosceles triangle with a height of approximately 0.15 and 0.50 millimeters, depending on the radius of the tubular element and the thickness of the wall of the tubular element.

[0018] The transfer of the excessive compressing force of the pressure roller onto the supporting occlusal path prevents crushing or the occurrence of undesirable or even harmful force against the tubular element as a result of the movement of the pressure roller. The pressure roller rolls against the occlusal surface so as to avoid the crushing of the tubular element by an excessive force. It either cannot sink deeply into the tubular element by excess force and cannot create an undesirable shift force applied to the tubular element in the direction of its longitudinal axis. The level of the pressure exerted by the pressure roller is adjusted automatically for variable working conditions of the pump

by redistribution of the total pressure force between the grooved working path with the inserting tubular element and the supporting occlusal surface. The fixed distance of the occlusal surface from the transversely grooved working path defines the extent of the grasping of the tubular element along the occlusal path. The positioning of the first and second supporting surfaces away from groove of the occlusal path assures that the volume ejected by the pressure roller from the pump segment is only a result of the radial application of force onto the tubular element.

[0019] The source of pulsing caused by repeated releases of the compressed flexible tubular element cannot be removed. Any cyclical drops and increase of the ejected medium from pulsing at the pump outlet in one cycle can be removed mechanically if the mutually correct correlation of geometrical dimensions is observed. In particular, this is achieved by the equal lengths of the occlusal path and the releasing path for the guiding of the tubular element from the occlusal path. It is also caused by the constant increment of the volume of the tubular element at the gradual release of the pressure of the pressure roller on the releasing path related to any unit of its length regardless of the manner in which the tubular element is mechanically clasp within the occlusal path. Mechanical linearity of the peristaltic rotation pump in accordance with the present invention is ensured by the equal angle and lengths of the first and second supporting surfaces defining the occlusal and the releasing paths. This condition is also achieved by the three-or more-arm rotor.

[0020] The pump rotor arms are symmetrically arranged in a circle. The minimum length of the main occlusal path of the pump is the result of the formula in which 360° divided by the number of pump rotor arms. In the case involving the preferred embodiment of the present invention, the minimum length of the main occlusal path of the pump rotor is 120°.

[0021] With zero back pressure at the pump output, only minimum pressure of the pressure roller is sufficient for closing the tubular element's cross section. Any excessive force caused by the springs is compensated by reaction of the supporting occlusal surface onto which the pressure roller rolls. When the back pressure increases, it is necessary to increase the pressing force of the pressure roller. This happens automatically by reduction of the force applied by the same pressure roller on the supporting occlusal surface.

[0022] The pressure roller of either of the pump rotor arms rolls on the supporting occlusal surface at the place of concurrence and also along the tubular element placed along this working path. The pressing force of the roller is carried out by the sliding mounting of its surface in the pressure block. As a result, these advantages are achieved by the unique combination of the rolling and sliding friction of the pressure roller of the peristaltic rotation pump. This holds the reaction of the pressing force of the pressure roller and the sliding mounting of the pressure block of the pump rotor.

[0023] The position of the pump rotor in the pump housing occurs without dislocation of the pump segment along its working path. This position is required for reaching high pumping accuracy. The hollow profile of the pump rotor allows for the receipt of the pressure blocks. This allows the use of a compact space of the large possible diameter. As a result, there is a large stroke of the pressure roller.

[0024] The easily disconnectable attachment of the pump rotor onto the shaft of the step motor facilitates the ability to adjust the clearance of the rotor with respect to outer housing.

[0025] It is an object of the present invention to provide long-term and stable fixation of the tubular element along the working path of the pump.

[0026] It is another object of the present invention to provide an exactly defined distance between the pressure roller and the tubular element at each point along the pump working path.

[0027] It is a further object of the present invention to provide a mechanical split of the working path of the pump into two paths of identical length. These paths include the occlusal path of the pump and the releasing path for guiding the tubular element out of the occlusal surface of the pump. There is also a lead-in path of any length for guiding the tubular element into the occlusal path of the pump. These paths define the working path of the tubular element of each pump.

[0028] It is a further object of the present invention to provide a mechanically constant increment of the tubular element volume by gradual releasing of the pressure roller from the tubular element located by the release path for leading the tubular element out of the occlusal path.

[0029] It is a further object of the present invention to provide pumping linearity by removing negative influences on the particular pressure roller.

[0030] It is a further object of the present invention to provide accuracy and long term stability of the pump so as to enable further substantial increases in doses accuracy through the use of microprocessor calibration.

[0031] It is an object of the present invention to provide a peristaltic rotation pump that can be easily manufactured in a uniform manner.

[0032] It is still a further object of the present invention to provide peristaltic rotation pump which avoids irreversible deformation of the tubular element.

[0033] It is a further object of the present invention to provide a peristaltic rotation pump which is exact and mechanically linear without regard to manufacturing tolerances on the individual mechanical components.

[0034] It is another object of the present invention to provide a peristaltic rotation pump which creates linear dependence on the dosed volume based upon the angle of rotation of the rotor.

[0035] It is still a further object of the present invention to provide a peristaltic rotation pump that is cheap to manufacture and does not require special installation or mechanical calibration.

[0036] It is a further object of the present invention to provide peristaltic rotation pump which has an extended life and a simple operation.

[0037] It is a further object of the present invention to provide peristaltic rotation pump that requires a minimal amount of training.

[0038] It is still another object of the present invention to provide peristaltic rotation pump which allows a wide range of pumping parameters to be achieved from micro-litters to tens or hundreds of litters by a simple change of a few design parameters.

[0039] It is still another object of the present invention to provide peristaltic rotation pump that can be switched during the operation by a control in both direction of rotation with no change in accuracy and linearity of pumping.

[0040] It is still a further object of the present invention to provide peristaltic rotation pump in which liquids as well as gases can be pumped and dosed with the same accuracy.

[0041] It is still a further object of the present invention to provide peristaltic rotation pump that allows dosage accuracy to be achieved with minimal costs and to be used in a highly pure environment.

[0042] It is another object of the present invention to provide peristaltic rotation pump which has minimal manufacturing costs while achieving the desired accuracy so as to enable the pumps to be

used where accuracy is not the decisive parameter, such as supplying nutrition in the digestive system, endoscopic operation of knees, sucking liquids from wounds, dialyses monitors, etc.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0043] FIGURE 1 illustrates schematically the arrangement of the outer housing with the pump segment and rotor located therein.

[0044] FIGURE 2 is an enlarged isolated view showing the illustration of circled area D from FIGURE 1a.

[0045] FIGURE 2 is an exploded perspective view of the peristaltic rotation pump of the present invention.

[0046] FIGURE 3 shows a rearward upper perspective view of the pump as dismounted from the outer housing.

[0047] FIGURE 3b shows a rearward upper perspective view of the pump as dismounted from the outer housing.

[0048] FIGURE 4 is a perspective view showing an exploded view of the dismounted pump.

[0049] FIGURE 5a shows a frontal upper perspective view of the rotor body.

[0050] FIGURE 5b shows a rearward upper perspective view of the rotor body.

[0051] FIGURE 6a is a frontal upper perspective view of a pressure block.

[0052] FIGURE 6b is a rearward upper perspective view of a pressure block.

DETAILED DESCRIPTION OF THE INVENTION

[0053] The peristaltic rotation pump of the present invention includes a tubular element 1 having an external diameter of 3.9 mm placed along an inner surface of an outer housing 24. The outer housing 24 has a diameter of approximately 65 mm. A three-arm rotor 6 is shown as having pressure rollers

4. The tubular element 1 is a tube utilized in an infusion set that is normally available in medicine. A working path 2 is defined along an inner surface of the outer housing 24. This working path 2 is grooved at the point of contact with the compressed tubular element 1. As will be described hereinafter there is an elevated supporting occlusal path 3 along which the pressure rollers 4 roll. The pressure rollers 4 are slidably mounted in pressure blocks 5 fitted in arms 23 of the rotor 6. The pressure roller 4 is a cylindrical member or a rolling bearing having a diameter of approximately 9mm. The pressure rollers 4 can be formed of hardened and lapped steel. The rotor 6 has a three-arm hollow profile 7. The pressure blocks 5 are loaded within the hollow area of the arms 23. Springs 8 are positioned within each of the arms 23. The springs 8 are located in the pressure blocks 5 and separated by a longitudinal partition 13. The springs are pre-stressed against the body 22 placed in the hollow profile 7 of the rotor 6. The body 22 has a trilateral prism shape having rounded corners 35. The rounded corners 35 fit into the socket 34 of the hollow profile 7 of the rotor 6 in the area of the connection of the arms 23 of the hollow profile. The body 22 has a cylindrical protrusion 29 at the front thereof. A securing spring 17 is placed thereagainst. A securing groove 19 is placed in the back side of the body of the body 22, along with an input groove 20, for securing pin 21 extending from shaft 9 of the motor 10. The width of the securing groove 19 at the location most distant position is shaft 9 is narrower than the diameter of the securing pin 21.

[0054] The tubular element 1 is mechanically compressed along the working path 24. In particular, there is first supporting surface 15, a second supporting surface 16 and a working path 2. The ends of the tubular element 1 will reside against the supporting surfaces 15 and 18. The supporting occlusal surface 3 is elevated above of grooved occlusal path 2 by the distance of approximately 1mm. The pressure block 5 is provided with a guiding groove 11 for guiding the tubular element 1

along the grooved working path 2. The stroke of the pressure block 5 is 7 mm. This is in the range of approximately 1.1 to 2 time the external diameter of the tubular element 1.

[0055] The pressure blocks 5 are secured within the rotor 6 by the use of a pin 12 placed in the front on the longitudinal partition of the pressure block 5. The pin 12 locks into the first grooves 14 symmetrically located inside the hollow profile 7 of the rotor 6. At the same time, the pin 12 also locks into the second groove 33 of the control element 32. Control element 32 is designed for handling the pressure blocks 5 when the rotor 6 is being mounted to the working path 2 into which the tubular element 1 is pressed by expansion. The control element 32 is threadedly connected to the cylindrical protrusion 29. The groove 14 has a length of approximately 7mm. The rotor 6 is connected by the body 22 to the shaft 9 of the step motor 10 and support by securing spring 17.

[0056] The pressure roller 4 is an electric conductor. As an electrical conductor, it can contact the speed contact 25 or the position contact 26 located on the supporting occlusal surface 3 at the point of the change from the lead-in path 15 to the occlusal path 2. There is a common contact 27 located against them on the edge of the occlusal path 2. The electric current applied is of a very low voltage.

[0057] In order to prevent unintentional rotation of the control element 32 during operation of the pump, there are depressions 30 into which protrusions 31 lock onto the front side of the hollow profile lock 7.

[0058] In order to operate the present invention, the tubular element 1 is placed into the grooved working path such that the tubular element 1 covers the lead-in path 15, the occlusal patent 2 and the releasing path 16. The pressure blocks are shifted into the arms 23 of the hollow profile 7 of rotor 6 by use of the control element 32. As such, the rotor 6 is ready for free sliding into the outer housing 24. The input groove 20 of the body 22 is turned parallel with the locking pin 21 placed on the shaft

9 of the step motor so as to slide the rotor 6 on the shaft 9. It is the pressed against the securing spring 17 and turn by 30°. Afterwards, pressure is released against the rotor 6. The pin 21 of the shaft 9 of the stepping motor 10 then locks in the securing groove 19 in the body 22 and the motor is connected to the rotor 6 without any play.

[0059] When the control element 32 is turned backwardly, the pressure blocks 5 slide out of the arms 23 of the rotor 6. As a result, the pressure rollers 4 will lean against the supporting occlusal surface 3 and also against the tubular element 1 located along groove of the outer housing 24. At the same time, the guiding grooves 11 of the pressure blocks 5 are ready to guide the tubular element 1 transversely along the working path 2.

[0060] During each actuation, the peristaltic rotation pump of the present invention carries out an automatic functionality self-check by way of the electric position contact 26. This senses the position of the pump rotor 6. The contact between the pressure rollers 4 and the contactors 26 and 27 causes a conductive connection. The electronic system immediately, and with high accuracy, determines the number of steps of the stepping motor necessary to repeated turn of the rotor 6. The unit thus tests correct operation of all the moving parts of the pump rotor 6 as well as accuracy of adjustment of the pressing force of the pressing springs 8. The pump is thus able to determine the condition when it cannot or can ensure the correctness and accuracy of pumping.

[0061] In order achieve pumping, the tubular element 1 is connected into a vessel with the pumped medium and the output hose. The output hose can be used so as to dose the medium into and external or extrinsic system. After switching on the peristaltic rotation pump of the present invention, the pump system fills the hoses and the tubular element by electrical rotation of the rotor 6. In order to adust the volume to be dosed it is necessary to calculate the number of steps of the stepping motor.

By pressing a start button, the rotor 6 of the peristaltic rotation pump starts turning and the programmed exact and linear pumping begins.

[0062] The pressure roller 4 of one of the arms 23 of rotor 6 moves along the supporting occlusal surface 3 between the input and output hoses. As the rotor 6 turns, it presses onto the tubular element 1 so as to reduce its cross section. Complete compression of the tubular element 1 by the pressure roller 4 always occurs at the most distant point 28. As the rotation of the velocity of the rotor 6 increases, a higher viscosity of the pumped medium can occur by the proper compression caused by the pressure roller 4. When the pressure rollers 4 does not connect either of the speed contact 25 with the common contact 27, the electronic system interprets the speed and slows down rotation. As a result, the connection of the position contact 26 (located by approx. 4° in the direction of the rotor 6 rotation in relation to the contact 25) with the contact 27 will occur. This defines the beginning of the occlusal path 2 and also assures the reliability of the compression of the pressure roller for any rotation speed of the rotor 6. As a result, pumping correctness is achieved. The pump, in this mode of operation of maximum pumping, speeds up and guarantees correct compression of the tubular element at the beginning of the occlusal path 2 and, also, assure the accuracy of pumping.

[0063] The pump is thus able to determine and not to exceed the maximum pumping speed. As a result, it guarantees correctness and accuracy of pumping even under variable operation conditions.

[0064] The moment of compression of one of the pressure rollers 4 on the tubular element 1 and also on the contactor 26 the preceding pressure roller 4 is at the end of the occlusal path 2 and at the beginning of the releasing path 16. A further slight turn of the rotor 6 shifts the above mentioned preceding pressure roller 4 toward the releasing path 6. This causes the opening the tubular element

1. Each further movement of the rotor 6 causes progressive release of the pressure roller 4 from the tubular element 1 so as to release a constant volume of the fluid therefrom.

[0065] The pumped medium is forced out of the tubular element 1, and thus out of the pump output by the pressure roller 4, which is moving at that moment on the portion of the tubular element 1 adjacent to the occlusal path 2. The preceding pressure roller 4, which is moving on the tubular element 1 adjacent to the releasing path 16, does not influence the pressure force of the pump since the space within the tubular element 1 before and after this roller 4 is connected and gradually filled with the medium forced by the next roller 4 moving on the tubular element 1 on the occlusal path 2.

[0066] After pumping the peristaltic rotation pump will switch off. By turning the control element 32 of the rotor 6, the pressure blocks 5 slide inside the arms 23 of the hollow profile 7 of the rotor 6. Axial pressure on the rotor 6 causes higher compression of the spring 17 fitted in the hollow cylindrical protrusion 29 of the body 22 against the shaft 9 of the motor 10. The securing pin 21 is released out of the securing groove 19. By turning the rotor to the left the securing pin 21 moves opposite the output groove 20 and the rotor 6 may be pulled off of the shaft 9 of the motor 10. By turning the control element 32 in the opposite direction, the pressure blocks 5 slide out and their pressing springs get partly released. Then, the tubular element 1 is pulled out of the groove of the outer housing 24. The ends of the tubular element 1 can then be removed from the supporting surfaces 15 and 18.

[0067] The foregoing disclosure and description of the invention is illustrative and explanatory thereof. Various changes in the details of the illustrated construction can be made within the scope of the appended claims without departing from the true spirit of the invention. The present invention should only be limited by the following claims and their legal equivalents.